Application Note
AN-18B

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Notes on Setting Up Hi-Des DVB-T, Modulator & Receiver

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Application Note, AN-17, introduced the reader to the new DVB-T products from the Taiwan company, Hi-Des Technology (www.hides.com.tw) [1]. The purpose of this note is to give a more details on how to initially set up the Hi-Des equipment, and in particular with KH6HTV Video products, especially our RF Linear Power Amplifiers.

Fig. 1 HV-100EH front panel showing controls

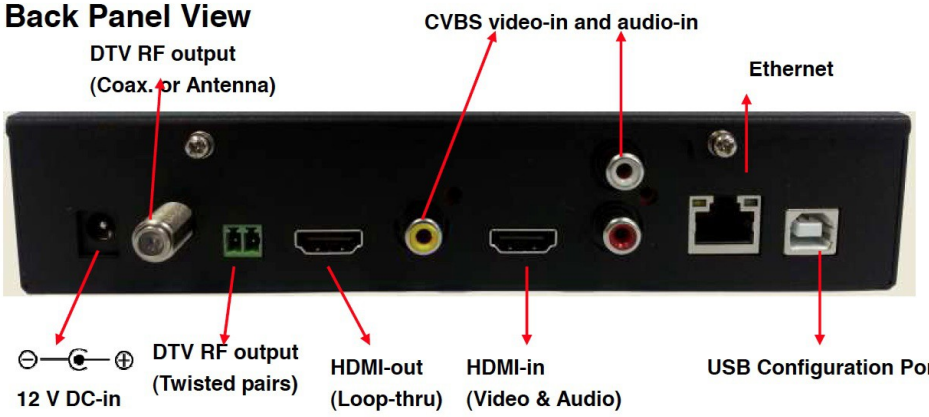

Fig. 2 HV-100EH rear panel showing the location of the various connectors.

HV-100EH DVB-T Modulator

***NOTE (3/23/17)**: Hi-Des has recently discontinued the model HV-100EH in favor of their newer model HV-102EH. The instruments are very similar and the programming setup is the same. The significant differences are: (1) The analog composite video plus stereo audio inputs have been deleted. (2) A BNC, SDI video/audio input has been added. SDI (Serial Data Interface) is the video industry standard for transporting digital A/V signals around a TV studio. The most common SDI data speed is 270Mbps. (3) The HDMI loop-thru output has been eliminated. (4) Hi-Des now supplies as an included accessory a composite video plus stereo audio to HDMI external adapter. (5) It supports Ethernet network video streaming input/out. (6) RF bandwidth adjustable from 1 to 8MHz (7) The HV-102EH sells for a bit lower price at $504 each.*

Hi-Des does provide a good instruction manual for the HV-100EH modulator, Figures 1 & 2. The purpose of this application note is to add additional details on how to use it. The function of the modulator is to take consumer grade video signals (either standard definition, composite video and stereo audio or HDMI), digitize the analog video and audio, encode it using either MPEG-2 or H.264 (MPEG-4-AVC), and then to modulate it onto an RF carrier using either QPSK, 16-QAM or 64-QAM. It adheres to the European Digital, Terrestrial, Broadcast TV standard, DVB-T (EN-300-744) [2].

The key RF specifications for the modulator are: (1) Frequency coverage: 50 to 950 MHz, and 1200 to 1350 MHz in 1 kHz steps. It thus covers the amateur radio 70cm (420-450 MHz), 33cm (902-928 MHz) and 23cm (1240-1300 MHz) bands. (2) Bandwidth selectable from 2 to 8 MHz in 1 MHz steps. (3) RF output power: -3dBm into 50 Ω for 70cm band (-18dBm 1200-1350 MHz). (4) Programmable Attenuator: +6dB gain to greater than -20dB attenuation in 1 dB steps.

The key video input/encoding/modulation specifications for the modulator are: (1) Analog Input (composite), standard definition 480i/30 NTSC or 576i/25 PAL plus line level stereo audio. (2) HDMI A/V Input , both NTSC and PAL supported, std. def. 720x480x30i up to full high definition 1920x1080x60p. (3) Ethernet Network Video Sreaming Input or Output (4) Video Compression: either MPEG-2 or H.264 (5) Audio Compression: either MPEG-2, AC3 or AAC. (6) Encoding Data Rate: adjustable, max. limits set depending upon other parameters. (7) Modulation (constellation): QPSK, 16-QAM or 64-QAM. (8) FFT (# of sub-carriers): 2K, 4K or 8K. (9) Forward Error Correction - Code Rate: 1/2, 2/3, 3/4, 5/6 or 7/8 and (10) Guard Interval (sync frame): 1/4, 1/8, 1/16 or /132.

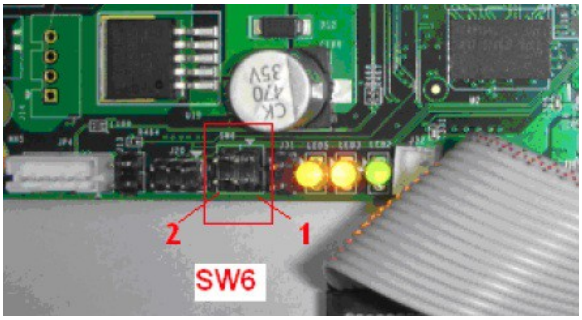

Fig. 3 Location of Bandwidth Jumpers

FIRST TIME OPERATION: When you first receive your modulator, you should check how it has been configured for bandwidth. Hi-Des designed this as a "universal" modulator to be used in countries world-wide. The TV broadcast standards vary from country to country. Bandwidths ranging from 5 MHz to 8 MHz are used. In the USA, the channel width is standardized by the FCC at 6 MHz. Therefore, you should check the internal jumpers on SW6, see Fig. 3, and move them as necessary to set the bandwidth to 6 MHz. See Hi-Des manual for details. You will still be able to custom program any bandwidth from 2 to 8 MHz for Ch 00-99, but the firmware channel look-up table will be only for standard broadcast TV, 6 MHz channels. These do NOT include frequencies in the amateur 70cm, 33cm nor 23cm bands.

The only front panel controls on the HV-100 (or HV-102) are for channel selection. To select a channel, use the Up/Down buttons to sequence the channel number until you reach the desired channel. When changing channels using the Up/Down buttons on the modulator, it has a "fail-safe" feature which prevents you from putting out a signal on any but the desired channel, or accidently changing the channel. You use the Up / Down buttons to move the channel number on the display until you reach the desired channel. Then you must next push the "OK" button to actually enter that particular channel.

Unfortunately, as the HV-100 (or HV-102) comes from the factory, you do not know what channels are really programmed into it. The manual does have several channel tables in it. All that appears on the front panel display is a channel number ranging from 00 to 99 with no frequency information. The factory might have attached a sticker indicating the frequency stored in channel 00, if you are lucky.

0, 423000, 6
1, 423000, 6
2, 429000, 6
3, 435000, 6
4, 441000, 6
5, 447000, 6

Fig. 4 Example, partial Custom Channel Table, listing standard, 70cm, 6MHz channels

For use on amateur radio band frequencies, you will need to install a custom channel table to program the various memories 00 thru 99, Fig. 4. You will be required to fill in a frequency and bandwidth for all 100 channels, even if you do not plan to use them. It is OK to repeat entries. The process of installing a custom channel table requires you to connect the modulator to a PC computer and run the Hi-Des supplied program called *AVSender*. More details below.

For first time operation, it is recommended that you simply connect the RF output of the HV-100EH (or HV-102) directly to the antenna input of a DVB-T receiver, such as the Hi-Des HV-110 or HV-120. To avoid overloading the receiver, a 20dB coaxial attenuator is recommended between the two units. Do not try to radiate a signal for your first

experiments. With a hard wired connection, you can operate on any of the modulator's preset channels without fear of creating RFI.

Now connect a video/audio source, such as a camcorder or DVD player to the modulator and also connect the +12Vdc power cable. You can use either a composite video or HDMI source. There is no DC power switch on the modulator. The only power switch is plugging in or removing the DC power cable. The modulator goes through a really slow power-up cycle of about 25 seconds booting up and initializing itself. First the Power On LED will illuminate, channel number 00 will next appear, then the current channel number will be displayed, and finally the Valid Video LED will be illuminated. Valid Video will only light up if an A/V signal is actually connected to the modulator.

If you are also using the HV-110, or HV-120 receiver for the first time, it will need to be Auto Scanned to find the signal. After the Auto Scan is complete, you should now see a "live" TV picture on your receiver monitor. Read the HV-110, or HV-120 manual for details. More details are also found later in this app. note.

If you are using a KH6HTV VIDEO model 70-14 DVB-T receiver, you do not need to worry about training the receiver. [3] It has already been pre-programmed by KH6HTV to receive the five (5), standard 6MHz band-width, 70cm, amateur band channels. Ch1 = 423MHz, Ch2 = 429MHz, Ch3 = 435MHz, Ch4 = 441MHz & Ch5 = 447MHz.

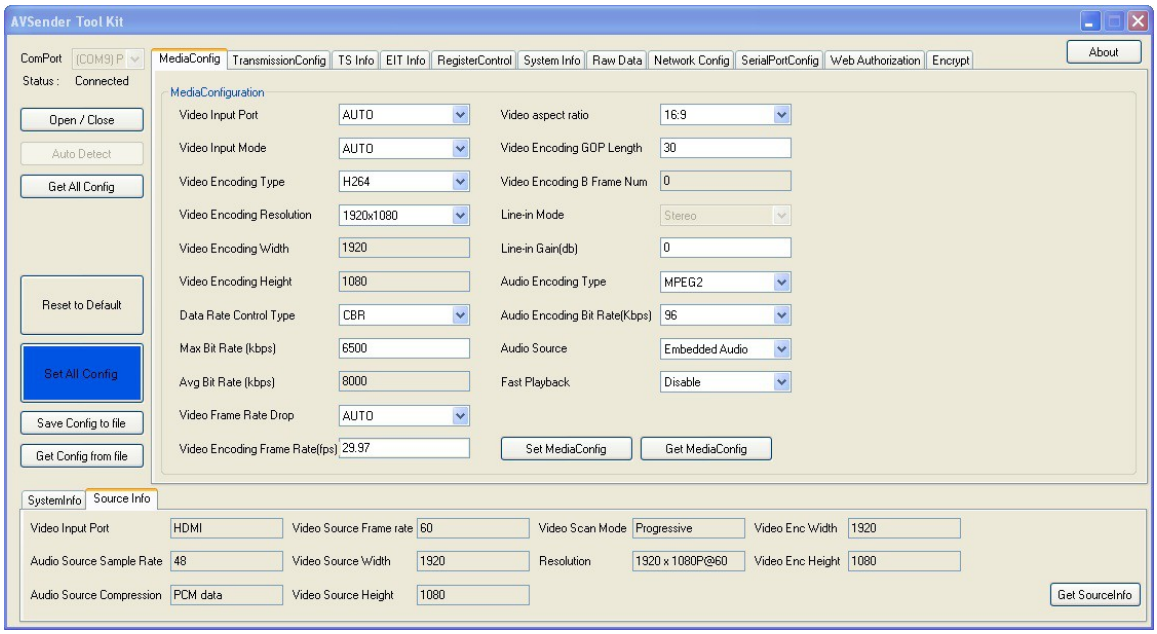

Fig. 5 ***AVSender Tool Kit*** -- initial screen shown on PC computer monitor screen. Media Configuration page --- shown with recommended settings for normal 1080P, 6MHz BW, QPSK operation

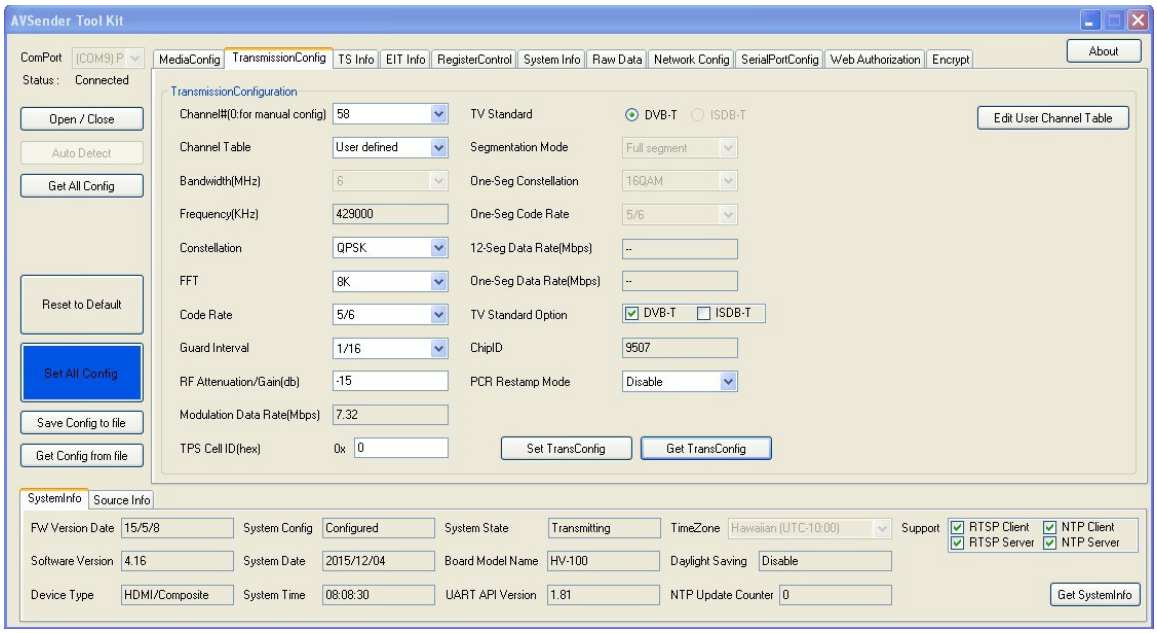

Fig. 6 ***AVSender Tool Kit*** Transmission Configuration --- shown with recommended settings for normal, 1080P, 6MHz BW, QPSK operation -- note: a custom channel table was used. "User Defined"

AVSender: While the HV-100 (now HV-102) is extremely easy to use, it does need to have several operating parameters initially set properly before normal operation on the amateur radio bands. This is done using an external Windows based, PC computer. The PC and the modulator are connected directly via a USB cable. Hi-Des supplies the necessary software on a CD disc. The control program is called: ***AVsenderUART-GUI***. The current version used in this discussion (3/24/17) is version 4.17. Updates to the software and firmware can be obtained directly from Hi-Des. Details on their installation are found in the instruction manual (also supplied on the CD).

If you have not already done so, the program *AVSender* and it's various drivers. needs to be installed on your PC computer. It only runs on Windows computers. It works on Windows XP (SP3) up to and including Windows 10. Versions can also be supplied by Hi-Des for Android and Nexus tablets or smart phones.

The control program is called: ***AVsenderUART-GUI***. For the incoming video/audio Media adjustable parameters include: input; Video Encoding, Audio Encoding, Data Rate Control, and Aspect Ratio. The HV-100EH automatically determines the parameters of the incoming video/audio stream and sets other parameters accordingly. The Transmission mode parameters that can be adjusted include: Frequency, Bandwidth; Modulation; FFT, FEC, Guard Interval and rf output level attenuation. The Hi-Des manual is good in showing you sample screen shots. The main three tabs in the *AVsender* program which you will want to later open and modify settings in are the "Media Config", "Transmission Config" and "TS Info". For your first time operation, it is recommended that you do not change any of the factory preset parameters with the

exception of the operating frequency and bandwidth. For your first test, it is suggested you start with Ch 00 or 01 set to 423000kHz and 6MHz bandwidth.

Channels / Frequencies: While you can use the modulator directly as it comes out of the packing box, in all likely hood, you will not be operating on a legal amateur radiofrequency for radiation of your DVB-T signal. Most of the channels available in the Hi-Des, factory installed, 6 MHz BW, look-up table are not in the USA amateur radio bands. For operation on frequencies in the amateur 70cm, 33cm, or 23cm bands, you will need to install a custom Channel Table, see above Fig. 4. See AN-10a [4] for tables listing the TV channels and frequencies normally used by USA amateurs. Also consult with other local TV amateurs to confirm the frequencies in use in your local area. They may not be the standard channels, nor band-widths. To custom program Ch 00 or install a custom table will require you to connect a Windows based PC computer to the modulator via a USB cable and run a program called *AVSender*. After the modulator has been reprogrammed, the USB cable and PC can be detached from the modulator. The custom channel table information will be retained in the modulator's memory, even after the DC power is turned off. The instruction manual, appendix A.5 gives details on creating and installing a custom Channel Table. After a custom channel table has been created, it can be stored as a .txt file on your PC. This file can also be edited offline with a standard text editor program. It can then be imported by *AVSender* and installed as a new channel table.

1st Use of AVSender: Only after you have the modulator properly powered up and with a valid video signal coming into it, and you have verified with a DVB-T receiver proper operation, should you attempt to make any other programming changes. Connect a USB cable between the modulator and the PC. Next launch the *AVsender* program, Fig. 5, you need to first click the button, "Auto Detect" (upper left corner). This determines which COM port your USB cable is on. Your status will show as "Disconnected". Next click the button "Open/Close" button. You will get a message saying "AV Sender: HV-100 connected" -- click "OK". You are now connected via USB to the modulator. The next step is to click the button "Get All Config". This queries the modulator for it's current settings and then displays them on your PC screen. See Figs. 5 & 6 above. When you do this for the first time, I suggest you take a "Screen Shot" of each of the various tab screens to keep as a record of the initial factory settings.

When changing any parameters, they do not automatically get transferred to the HV-100EH modulator. After you are satisfied with the parameters in a particular screen, you must click on the button "Set Config" to send the new settings to the HV-100EH.

Remember for programming a new frequency (channel), when it asks for a frequency, you enter the center frequency, not the band edge(s). For example at the low end of the 70cm amateur radio band, the first 6 MHz channel, Ch 57, extends from 420-426 MHz, but the center frequency is 423 MHz. Also the frequency is entered in kHz with 1kHz resolution, not in MHz.

A nice feature of digital TV is the ability to imbed in it's data stream the station call sign. This thus automatically satisfies the FCC requirement for identification of your transmitter. To do this, use the *AVSender* Tool Kit program and open the tab labeled "TS Info". Enter your call sign in the box labeled "Service Name". Then push the button labeled "Set TSInfo Config". You are now legal with the FCC for ID purposes.

TRANSMISSION PARAMETERS: The parameters of FFT, FEC and Guard Interval are extremely important in determining how well your TV signal will propagate and be decoded at the receiver under multi-path conditions. The settings on my HV-100EH modulator as it came from the Hi-Des factory were 64-QPSK, 2K FFT, 5/6 FEC and 1/16 Guard Interval. References [5 & 6] provide a good description of these parameters. The Constellation parameter selects the modulation method of either QPSK, 16QAM or 64QAM. The best video performance (but only in strong signal conditions) is obtained using 64QAM and the highest possible bit rate. For weak signal, typical of amateur useage, QPSK is recommended. The Guard Interval is used to synchronize the receiver. It is the same as sync pulses used in the old analog NTSC system. The Guard ratio determines how much of the total data frame is devoted to "sync". The Code Ratio, also called FEC or Forward Error Correction ratio determines how much data is devoted to error correction, versus the true live video data. 5/6 means for every 5 bits of real data, one extra bit is added for error correction. The FFT determines how many subcarriers are used within the channel bandwidth. The choice is either 2000 or 8000. (2K or 8K).

Another key parameter in the Media configuration is the encoding data rate, called "Max Bit Rate." To follow rapidly changing scenes, the highest possible data rate should be used. The max. theoretical possible data rate is a function of Bandwidth, modulation type, FEC and Guard Interval. Ref [6] tabulates all of the various possible options. *AVSender* also calculates and displays the theoretical maximum for any particular setting. It is on the Transmission page and called "Modulation Data Rate". It is grayed out indicating that you can not alter it. For a 6 MHz bandwidth, the theoretical maximum is 23.75Mbps for 64QAM with 7/8 FEC and 1/32 Guard Interval. For QPSK it is a much lower 7.92Mbps with 7/8 FEC & 1/32 Guard. The Hi-Des HV-100EH will not operate above 16Mbps. Trying to set any data rate too high, the Hi-Des defaults back to 8Mbps. However, operation at or near the theoretical maximum sometimes gave unacceptable breakups first in the audio and sometimes in the picture. In the most aggressive FCC (1/2) & guard interval (1/4) at QPSK, the data rate has to be set low enough (i.e. 2.5Mbps) that the picture becomes coarse pixels. It is best to experiment to find the highest rate consistent with good A/Vperformance, especially with fast motion images. In their instruction manual, Hi-Des recommends that the "Max Bit Rate" be set no higher than 80% of the theoretical max. "Modulation Data Rate." I adhere to the 80% recommendation. If you use a lower rf bandwidth, you will need to reduce the video resolution and bit rate. With a 2 MHz bandwidth, it is only possible to transmit standard definition, 480i video.

It should be noted that these above parameters can be changed and they will not alter the performance of a DVB-T receiver. Even when these parameters change on the fly, or

when switching from one ham's transmitter to another with different parameters, the receiver automatically tracks these changes.

RECCOMENDED PARAMETERS: I selected QPSK based upon the superior performance of a DVB-T receiver under weak signal conditions, (-97dBm vs. -82dBm for 64QAM). I selected using an FFT of 8K based upon the recommendation in reference [6] which stated "An 8K system allows reception with longer multi-path echos." 2K is supposed to be a better choice for Doppler shift corrections for mobile operations. I chose to use the factory presets of 5/6 FEC and 1/16 Guard Interval. Jim White, NC0JW, has confirmed that they are the same settings which CBS found in DTV propagation experiments to work best in most situations [7].

Recommended Modulator Settings for High-Def, 1080P

Media Configuration: video input port = AUTO (HDMI), video encoding = 1920x1080, H.264, data rate control = CBR, Max Bit Rate = 5800kbps, frame rate = 29.97, aspect ratio = 16:9, video encoding GOP length = 30, Audio encoding type = MPEG2, audio encoding bit rate = 96kbps, audio source = embedded audio

Transmission Configuration: bandwidth = 6MHz, constellation = QPSK, FFT = 8K, Code Rate = 5/6, Guard Interval = 1/16, (Modulation Data Rate = 7.32Mbps)
note: per Hi-Des 80% guideline, set Max Bit Rate = 5856 kbps

If you are in an extremely horrible multi-path environment and can not get a DVB-T signal through, then I suggest you experiment with more aggressive settings for the FEC and Guard Interval. Matt Holiday, KD0DVB, [8], the Boulder, CO DVB-T guru, has researched this issue and recommends the following:

Recommended Modulator Settings for High-Def, 1080P
under Compromised Multi-Path Conditions
FEC code rate = 2/3, guard interval = 1/32, CBR, data rate = 4800kbps (Modulation Data Rate = 6.03Mbps) (some coarse frames might result on some images)
note: per Hi-Des 80% guideline, set Max Bit Rate = 4824 kbps

Recommended Modulator Settings for High-Def Video
under Extremely Poor Multi-Path Conditions
Drop video resolution to 720P (1280 x 720), FEC code rate = 1/2, guard interval = 1/32, CBR, data rate = 3600kbps (Modulation Data Rate = 4.52Mbps) (Does not track rapid scene changes well. freezes frames)
note: per Hi-Des 80% guideline, set Max Bit Rate = 3616 kbps

RF LINEAR POWER AMPLIFIERS

Any of the KH6HTV VIDEO rf, linear, power amplifiers can be used successfully with the Hi-Des model HV-100EH (or HV-102EH) modulator to make a complete DVB-T

Transmitter. While our amplifiers are quite linear, they will still introduce some spectral regrowth on the out of channel skirts of the DVB-T spectrum The rf input drive level needs to be carefully set to avoid overdriving and creating excessive spectral regrowth. Fig. 7 shows the spectrum directly from the Hi-Des modulator, while Fig. 8 shows the spectrum of a 3 watt avg. (+35dBm) output from a KH6HTV Video model 70-7B Linear Amplifier using the HV-100EH as the modulator driver.

Per the ITU, [6] the proper settings of a spectrum analyzer for measuring a DVB-T signal are as follows: span = 20MHz (i.e. 2MHz/div, horiz.), 30kHz resolution band-width, 300kHz video band-width, RMS average detector, 10 sweep averages, 2 second scan time.

The RF output level of the HV-100EH (& HV-102EH) modulator can be adjusted with an internal attenuator with an adjustment range of >20dB. This must be done using *AVSender* on a PC via a USB cable. However it has been found that at higher values of attenuation, the modulator has a defect in that it has a severe leakage of the center frequency carrier with a CW tone which seems to bypass the attenuator. Thus, it is recommended that the internal attenuator never be set lower than -5dB to minimize this leakage. Instead, if more attenuation is required, it should be provided using external, coaxial attenuators.

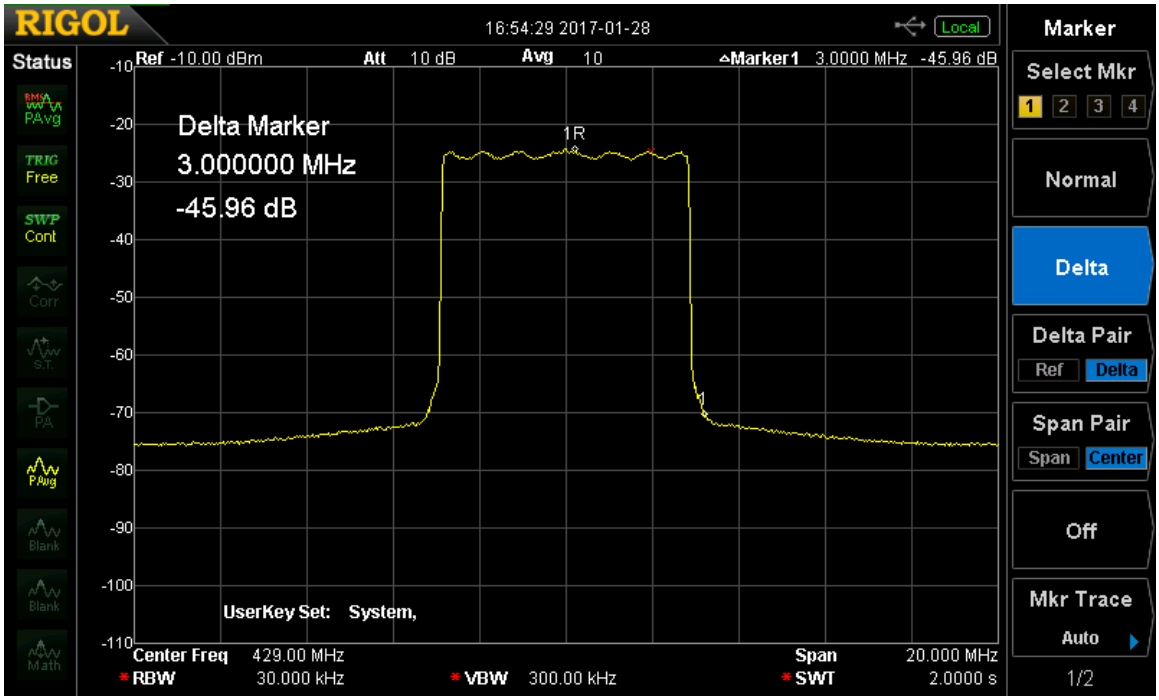

Fig. 7 DVB-T Spectrum -- output from Hi-Des model HV-100EH modulator. Vert = 10 dB/div. Horiz = 2 MHz/div Note spectrum shoulder break-point is approx. -46 dB below the flat top portion of the spectrum.

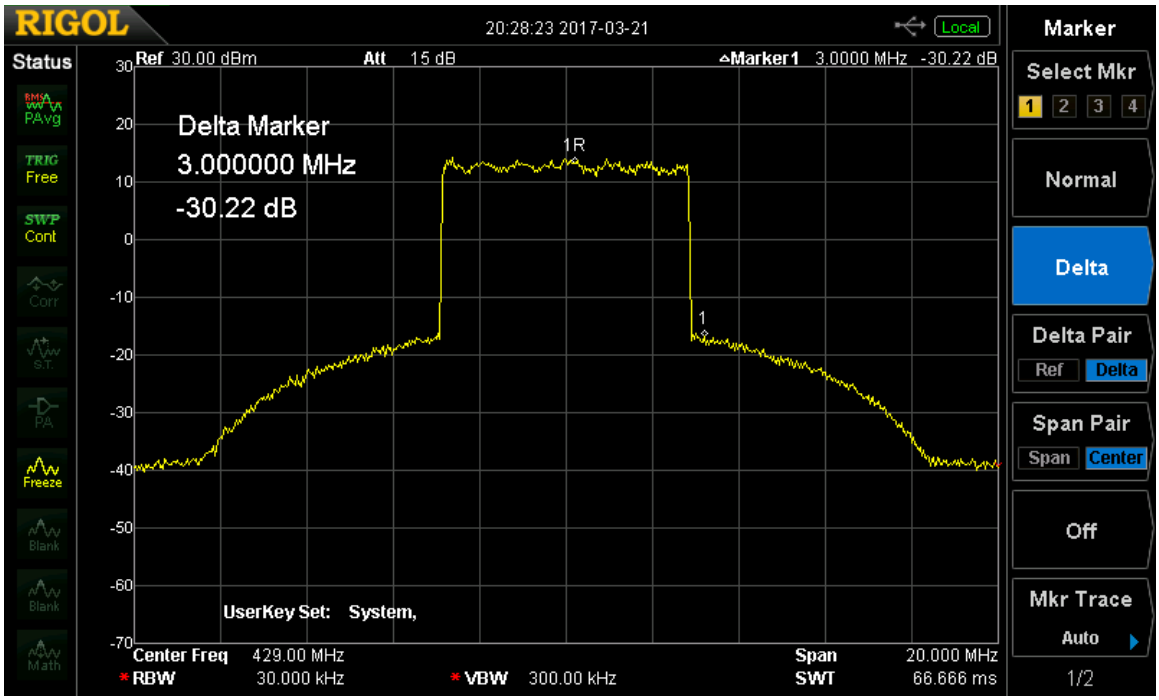

Fig. 8 DVB-T Spectrum -- output from KH6HTV VIDEO model 70-7B Linear Amplifier. Vert = 10 dB/div. Horiz = 2 MHz/div Note spectrum shoulder break-point is approx. -30 dB below the flat top portion of the spectrum.

Table 1 Proper RF Drive Levels for KH6HTV VIDEO Linear Amplifiers for DVB-T, QPSK (1)

Model #	Gain nominal	RF Input avg.	RF Output avg.	RF Output Watts
70-4B	20dB	-6dBm	+14dBm	25 mW
70-5B	39dB	-14dBm	+25dBm	300 mW
70-7B	50dB	-15dBm	+35dBm	3 W
70-9B	50dB	-10dBm	+40dBm	10 W
70-10AD	50dB	-15dBm	+35dBm	3 W
70-12C	53dB	-15dBm	+38dBm	6 W
33-1A	42dB	-9dBm	+33dBm	2 W
33-3B	50dB	-12dBm	+38dBm	6 W
23-11A	50dB	-15dBm	+35dBm	3 W

note 1 --- spectrum shoulder break-point = -30dBc

It is always a compromise between maximizing the rf output power versus minimizing the spectral energy outside the channel pass-band. Driving an amplifier harder will increase the output power, but also degrade the spectral regrowth. The decision was made to run the rf drive input power up until the spectrum shoulder break-point grew to -30dBc. This is consistant with commercial broadcast standards. However, commercial DTV transmitters then also use feedback and digital pre-distorion, plus sharp cutoff channel filters. The specs. are based upon this. Table 1 lists the typical drive level settings to use for the various amplifier models. The frequency response of most

amplifiers is not completely flat across the band, nor is the actual gain exactly as listed for the "nominal" value. The best approach is to consult the test report which came with your amplifier to determine the actual gain at the frequency of interest. Calculate Pin = Pout - Gain.

The output power and the internal attenuator in the Hi-Des HV-100EH modulator is quite accurate in the 70cm band. The output power rating for the HV-100EH is -3dBm when it's internal attenuator is set to 0dB. The output power from the modulator is thus = -3dBm - attenuator(dB). The output power of the HV-100EH is not accurate for the 33cm nor 23cm band. With it's attenuator set to +6dB gain, the absolute max. output power was found to be only -5dBm at 23cm.

The HV-100EH output power is set by programming the Attenuator on the *Trans Config* page of *AVSender*. The Atten setting holds for all channels. Unfortunately, it can not be programmed uniquely for each individual channel.

HV-110 & HV-120 DVB-T Receivers

Fig. 9 Hi-Des model HV-120, DVB-T Receiver front and rear panels

The Hi-Des companion DVB-T receiver to the model HV-100EH modulator is their model HV-110 and also a newer model HV-120, Fig. 9.

(3/24/2017) Note: Hi-Des has also introduced a newer model with enhanced features. It is their model HV-120. [9]. Significant differences include: (1) frequency coverage 100-950MHz plus 1150-2650MHz (2) two SMA antenna inputs low band (<1GHz) and high band (>1GHz), (3) +12Vdc power (4) bandwidth switch eliminated, & (5) $209

The HV-110 is a very small, "set-top" converter box. These HV-110 notes relate to the firmware download of version (0.0.1.72.83.0). It is extremely simple to operate. It operates on +5Vdc. The +5V can be connected either via a DC power plug or a mini-USB cable. Hi-Des supplies a 5Vdc USB wall wart ac supply and a USB cable. There is no on/off switch. The receiver is always on when it is receiving 5Vdc power. The only switch is the bandwidth switch on the rear panel. It must be set to the proper setting prior to applying DC power. Down is 2,3 or 4MHz. Up is 5,6,7 or 8MHz. The switch

setting is only read upon initial power up. The RF IN is an SMA (f) connector. Composite video plus stereo audio comes from a miniature 1/8", multi-conductor jack. Hi-Des supplies a suitable cable with breakouts to RCA connectors (yellow = video, red/white = audio). The other connector is an HDMI output. Note: the composite output only works when the resolution is set to 480i standard definition.

Table 2 --- Receiver Sensitivities of HV-110 & HV-120
(QPSK, 6MHz BW, 8K FFT, 5/6 code, 1/16 guard, H.264, 1080P)

Model #	70cm	33cm	23cm
HV-110	-94dBm	-93dBm	NA
HV-120	-95dBm	-96dBm	-87dBm

Measurements have been made of the receiver sensitivities of the HV-110, HV-120 and other DVB-T receivers [10]. For the HV-110 and the HV-120, the results are summarized in Table 2. It should be noted that the 23cm sensitivity of the HV-120 is poor and an external pre-amp should always be used with it on 23cm band. Using a model 23-4LNA pre-amp, the sensitivity is increased dramatically by 10dB to -97dBm. Measurements were also made to compare various modulation methods. With the HV-120 on 70cm, the results were: -95dBm (QPSK), -90dBm (16QAM) & -82dBm (64QAM), thus demonstrating the superiority of QPSK for weak signal amateur service.

It should be noted that the Hi-Des model HV-110 Receiver does not have as wide a frequency coverage as the model HV-100EH Modulator. The modulator covers completely the amateur radio 70cm (420-450MHz), 33cm (902-928MHz) and the 23cm (1240-1300MHz) bands. The HV-110 Receiver only tunes from 170 to 950MHz, which includes the amateur 70cm and 33cm bands. For receiving coverage of the amateur 23cm band, or the higher microwave bands, either a down-converter or the model HV-120 receiver is required. We have found that the local oscillator in the down-converter must have extremely low phase noise. The DVB-T receiver is extremely intolerant of any FMing on the LO.

All communications with the HV-110 or HV-120 receiver are accomplished using the supplied remote control. The USB connection on the rear panel of the HV-110 is only for dc power input. The main things you will be using the remote for are to set the display resolution (480i up to 1080p), to set the desired receive frequency (channel) and to access the diagnostics readouts.

CHANNEL PROGRAMMING: For most amateur radio operations, we will not be using the pre-programmed channels stored in the HV-110 firmware. Instead, you will usually be custom programming to match the frequencies (channels) used in your local geographic area. The Hi-Des instruction manual is quite informative on how to do this. Use "Channel Scan - Manual Mode". See pages 11&12 in the manual (v1.0_20140627). Remember, when it asks for a frequency, you enter the center frequency, not the band edge(s). For example at the low end of the 70cm amateur radio band, the first 6 MHz channel extends from 420-426 MHz, with a center frequency is 423 MHz. You can pre-load into the receiver an entire list of all the amateur TV channels you want to use. This

capability is not mentioned in the manual. Connect your DVB-T modulator directly to the receiver via a coaxial cable. A 20dB attenuator between the two units is recommended to avoid overloading the receiver. Start at the lowest frequency (channel) you want to store. Set your DVB-T modulator to put out a signal on this frequency. When the receiver Installation menu asks "Do you want to clear the channel list" -- select "Yes". Then change the modulator's frequency to the next frequency you will want to use. Again use the installation menu to store this frequency, but when it asks "Do you want to clear the channel list?" -- select "No". Continue this process for all the desired frequencies (channels), each time selecting "No" for clearing the channel list. It is suggested to avoid later confusion, that you program the receiver channels in ascending order to match the modulator's custom channel table channel numbers.

Note: The two digit LED display on the front panel displays the channel number in the sequence in which they were auto-scanned into the instrument. It reads from 01 to 99. It does not display the frequency. There are two push buttons on the front panel. They allow one to increment up or down the channel number without resorting to the remote control. The front panel LED is useful. When it glows 'Green' it indicates a Valid DVB-T Signal is being received. When it glows "Red', no valid signal is present.

Fig. 10 HV-110 or HV-120 On Screen Display

ON SCREEN DISPLAY: A nice feature of both the HV-110 and HV-120 for determining your RF path propagation characteristics is the "Signal Statistics" On Screen Displays (OSD) which provide a lot of details about the incoming signal. Pushing the Green button on the remote control gives a lot of details. However, it overlays the desired picture and "grays" it out. Pushing the Yellow button on the remote gives a brief description of the signal, including: frequency, bandwidth, Signal Quality, Signal Strength, etc, but also grays out the screen image.

The most useful OSD diagnostic is to push the Yellow button on the remote control twice. This gives you the normal received picture, but also places four small boxes in the corners of the screen. See Fig. 10. In the upper left is the center frequency and bandwidth. In the lower left is the ID call sign of the station being received. In the upper right corner is the received signal strength in dBm. In the lower right corner is the received signal to noise ratio in dB. Pushing the Yellow button the third time turns off these OSD boxes.

The signal strength calibration of the HV-110 in a lab environment with only one signal present was found to be extremely accurate within ±1dB over a range from -10dBm to -90dBm. Signals weaker than -90dBm were not accurately measured. In a typical field environment with multiple signals coming in from an antenna, the dBm reading tends to read the composite power of all the input signals.

The OSD signal strength display of the HV-120 was found to have a very large error. It's linearity was good. It tracked 1dB change in input gave 1dB change in the OSD. The actual OSD values displayed were found to have a large offset error. It read +14dB too high on 70cm and +25dB too high on 23cm.

The S/N reading is useful for understanding the quality of the incoming signal and the amount of error correction needed. Under perfect conditions, the max. s/n reading is typically 22 to 23dB, for QPSK. When the s/n drops down to 7 to 8dB, the receiver can no longer decode the signal. (for QPSK, FEC = 5/8, Guard = 1/16). With more aggressive FEC and Guard Intervals, a worse (i.e. lower) s/n can be tolerated. For 16QAM, the max. s/n = 26dB, while for 64QAM, the max. s/n = 29dB.

A minor aggravation of both the HV-110 & HV-120 OSD is the transmitting station identification shown in the lower left hand corner of the OSD. It only displays the ID of the station which was transmitting at the time the receiver was auto-scanned to initially train the receiver. It does NOT display the ID call sign of the current station being received.

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